

ART. XVII.—*Contributions to our Knowledge of
Australian Earthworms.*

THE NEPHRIDIA.

BY FREDA BAGE, M.Sc.,

Government Research Scholar in the University of Melbourne.

(With Plates XLIV.–XLVII).

[Read 9th December, 1909].

For some years past Professor Spencer and Mr. J. J. Fletcher have been engaged in describing a large collection of Australian earthworms, chiefly those of the eastern and south-eastern coastal districts.¹ As their collections have increased in size they have found it necessary to describe new species, putting them temporarily into certain genera until the classification of the earthworm fauna should be more satisfactory. To prepare the way for such a classification much anatomical work is needed, and at present a series of investigations is being carried out in the Melbourne University. Dr. Georgina Sweet and Miss Gwynneth Buchanan have published work on the spermiducal glands and bloodvessels respectively; Miss Janet Raff is engaged on work on the alimentary canal, and at the suggestion of Professor Spencer I have undertaken the part in connection with the nephridia. The work has been done in the Biological Laboratory of the University of Melbourne, and I take this opportunity of thanking Professor Spencer for the use of his large collection of Australian earthworms and for his advice and help on all occasions.

The genera dealt with are *Megascolex*, *Diporochaeta*, *Digaster*, *Perissogaster*, *Megascolides*, *Woodwardia*, *Notoscolex* and *Fletcherodrilus*, though only one or two species of each have been examined. In most of the forms the original description stated whether they

¹ A large number of earthworms from South-Western Australia has recently been described by Professor W. Michaelsen in his work "Die Fauna Südwest-Australiens," 1907.

were mega or micronephric, or sometimes plectonephric, and I have endeavoured to supplement this with some account of the general distribution of nephridia throughout the body, and where possible with microscopic structure. Throughout I have used the terms meganephric and micronephric, the latter in preference to Benham's word plectonephric, used in most of the original descriptions, but which he has himself since discarded in favour of micronephric.

The structure and arrangement of the nephridia vary to an enormous extent, but there are points of resemblance in some. and with further work on the Australian forms it appears that the nephridia may be of much use for systematic purposes.

For convenience I have adopted the nomenclature and classification of the genera used by Michaelsen in his account of the Oligochaeta of South-west Australia.¹

1.—**Megascolex dorsalis**, Fletcher ;

syn. *Perichaeta dorsalis*, Fletcher (8), p. 618.

No nephridiopores can be seen externally.

Both micro and meganephridia are present, a condition which Beddard (2), p. 370, regards as characteristic of the genus *Megascolex*, though as far as I can ascertain, meganephridia have not been figured before for this species.

Macroscopic Structure.—On dissection micronephridia are seen to be present throughout all the segments of the body. These are described by Fletcher (8), p. 618, as minute inconspicuous tufts of tubules. They are arranged somewhat irregularly over the body wall in the anterior segments of the body, becoming less numerous in the posterior parts, where the meganephridia are situated, and being arranged more or less regularly in a single row. In addition to these micronephridia there is a distinct series of well-developed meganephridia which are not mentioned by Fletcher or Spencer. These are absent from the segments anterior to the male pores, but from this point to the posterior end of the body there is a pair on the ventral surface of each segment with definite funnels opening on either side of the nerve cord. There is in this species also

¹ Michaelsen, "Die Fauna Südwest Australiens—Oligochaeta," pp. 117-232, 1907.

a curious additional pair of meganephridia present on the dorsal surface of the more posterior segments of the body. Each of these dorsal nephridia also has a well-developed funnel. The arrangement of the meganephridia was examined in one specimen which consists of 120 segments. [Fig. 1.] The micronephridia were present in every segment, ventral meganephridia in segments 21 to 120, while the dorsal meganephridia were present only in segments 50 to the posterior end. The parts of the nephridia were too small to be made out by dissection, but a fine thread could be seen connecting the two meganephridia. [Fig. 4.]

Microscopic Structure.—By means of series of sections the structure of the meganephridia was made out in part. Both dorsal and ventral tubules appear to be similar in structure, and to consist of the same series of parts. The structure of the funnel is different from that of any other species examined, the cells composing it being very few in number, apparently only five, and extremely large in size. [Fig. 2, c.] These are, as usual, ciliated, and the nuclei are distinctly seen in stained sections. The cells have their long axes parallel with the length of the body, and are somewhat irregular in shape; thus there is no arrangement to be compared with that of the regular marginal cells of other species. The funnel leads into an intracellular duct [Fig. 2, d.i.], the tubule containing which, after passing through the septum to the next posterior segment, divides into two portions [Fig. 3], each of which contains a mass of coiled intercellular ducts. A very fine intracellular duct joining the dorsal and ventral nephridia passes round the alimentary canal attached to the face of the anterior septum by a fine mesentery. The ventral nephridium apparently opens to the exterior by a fine duct which passes out through the muscles. No trace, however, could be found of any duct opening directly from the dorsal nephridium. This seems to point to the probability that the dorsal nephridium is simply a portion of the ventral one, which has, together with the spermathecae, come in this form to lie dorsally, and has acquired a secondary opening into the body cavity.

The micronephridia, although extremely minute, are very numerous, and are attached to the body wall of every segment

except the first. They are arranged irregularly and have no funnels, the tubule being simply a short coil containing an intracellular duct which continues from one nephridium to another, the exact connection of which, with irregularly placed minute openings to the exterior, I have been unable to make out. There is, however, as far as I have seen, no continuation of these ducts from one segment to another. In this species there are no peptonephridia.

2.—*Megascolex fielderi*, Spencer ;

syn. *Perichaeta fielderi*, Spencer (16), p. 19.

No nephridiopores are visible.

Both micro and meganephridia are present, the presence of the latter being indicated by the occurrence of funnels in certain segments of the body. Glandular tufts of nephridial tubules are present in the anterior segments, which are regarded as doubtful peptonephridia by Professor Spencer (16), p. 19, but which do not appear in my sections to open into the alimentary canal.

Macroscopic Structure.—When the earthworm is opened from the dorsal surface, nephridia are seen to be present in great numbers in all the segments, especially in the clitellar region. From about the twentieth segment to the posterior end of the body they are arranged in a fairly definite row in each segment, and are more or less attached to one another. No funnels can be seen in the anterior part of the body, but towards the posterior end the funnels become more and more numerous, as many as fourteen being counted in one segment. At the same time the characteristic row of nephridia does not alter. The position of the nephridial funnels seems to be quite irregular, and they vary in number in the different segments. In one specimen of 134 segments the funnels were counted. The most anterior one occurred in segment 93 on one side only. This was followed by one here and there [Fig. 5, F], back to segment 110, after which there were numerous funnels in each segment. The presence of the funnels does not seem to entail any perceptible difference in the size or number of the nephridia in each segment. Throughout the body, posterior to

segment 20 the nephridia are irregular in shape, and appear to be connected with one another by a loose band of tissue which, in its turn, is connected with the anterior septum of each segment. [Fig. 6.]

Microscopic Structure.—A series of sections confirms the general arrangement seen by dissection. Towards the posterior end of the body, the nephridia, into which the funnels open, are connected with one another by means of the loose connective tissue noted above. Through this ramify many ducts [Fig. 7], which soon pass off singly through the longitudinal muscles to what seems to be a sinus between the two layers of muscles. From this sinus branched ducts lead again to the exterior. I was unable to trace any one duct right through to the external opening, as they form such a confused network. Further, from my sections I could not decide whether or not there was a connection of the ducts from segment to segment, but apparently the sinus was continuous through all the segments examined. At the very anterior end there is a mass of nephridial tubules, one on either side of the pharynx, which were recognised by Professor Spencer as doubtfully peptonephridia. I have not been able to find any ducts opening from these to the alimentary canal, and Miss Raff, who is working on the structures connected with the alimentary canal, has not only failed to discover any connection with the pharynx, but has traced ducts from the tufts which open to the exterior, so that they must be regarded as a tuft of micronephridia, and not as peptonephridia.

3. *Diporochaeta davallia*, Spencer (17), p. 52.

The nephridiopores could not be distinguished with the naked eye, but on dissection the ducts from the nephridia to the exterior are seen to open at the level of the interval between the fourth and fifth setae from the ventral surface; that is, about halfway between the mid-ventral and mid-dorsal lines. (See also Spencer (6), p. 52.)

The nephridial system is meganephric.

Macroscopic Structure.—There are, except in the first and second segments, one pair of meganephridia in each segment.

In the first segment there are no nephridia, and in the second, a thick tuft of what are apparently micronephridia take the place of the ordinary pair. No funnel could be seen opening from this mass of tubules. Behind these two segments a conspicuous pair of meganephridia is situated in each segment. Throughout the body these nephridia appear to consist of the same parts [Fig. 8], though there is some variation in the thickness and length of the several coils in different regions. The nephridia towards the anterior end seem to be thicker walled and more closely coiled than those behind the spermiducal glands. The funnel [Fig. 8] is connected by a fine duct passing through the septum to a large coiled portion [Fig. 8, c.n.], averaging 3 mm. in length. One coil, the same in each nephridium behind segment 18, is curiously dark in colour, apparently containing pigment [Fig. 8, p.c.n.]. A fine thread passes out of the coil and along the body wall, entering it between the fourth and fifth seta from the ventral surface.

Microscopic Structure.—The funnel is relatively large, and is formed by columnar ciliated marginal cells which appear to be twenty in number, and are arranged in a very definite way in a single row. [Fig. 9, c.m.] From the funnel ciliated cubic cells are continued for a very short distance, and the lumen surrounded by these soon passes into the usual intracellular duct.

The pigmented coil mentioned above is well seen when the nephridium is mounted whole in glycerine. In section, the pigment appears to be present in the form of granules laid down in the substance of the cells lining the coil, the lumen of which is intracellular. [Fig. 10.] The nuclei are well seen in some of the sections. [Fig. 10, nucl.] Apart from the presence of the pigment granules, the histology of this coil is similar to that of the rest of the larger coils of the nephridia, being lined by large clearly-nucleated cells. There is no well-marked muscular duct, but its place is taken by a long intracellular straight duct [Fig. 8, i.d.], which, after traversing the segment for a short distance, enters the muscles and passes out through them to the exterior almost directly, the external opening being very small.

4.—*Diporochaeta grandis*, Spencer (17), p. 63.

Nephridiopores could not be distinguished in the one specimen available.

This species is meganephric.

Macroscopic Structure.—One pair of meganephridia occur in each segment after the first. These are arranged in the same coils throughout all the segments of the body, but change somewhat in character towards the anterior end. The most noticeable point about the nephridia is a curious single marginal duct [Fig. 11, m.d.], which passes in a definite way round a portion which is apparently the vesicle (V?).

Microscopic Structure.—Under the microscope the above duct is seen to be coiled in certain parts, straight in others, and intercellular. It forms a loop surrounding a definite flat layer or layers of connective tissue [Fig. 11, c.t.], and is quite conspicuous. There is some indication of the presence of a muscular vesicle [Fig. 11, V?], but as no sections were available, that is doubtful. The funnel is very definite in shape, being surrounded by a well-defined row of marginal cells. Just where the cavity of the funnel passes into the intracellular duct there is a curious mass of cells [Fig. 11, m.c.], quite definite in shape, and arranged round the preseptal portion of the intracellular duct. This appears to be comparable with the cells occurring in *Lumbricus*, figured by Benham (6), p. 297, and regarded by him as coelomic epithelial cells.

In the specimen of *D. grandis* examined, enormous numbers of small white spots appeared to be attached to nephridia. On examination these proved to be colonies of sporozoa, though I have not been able to identify them.

5.—*Digaster armifera*, Fletcher (6), p. 947.

No nephridiopores were visible.

The nephridial system is micronephric throughout, the anterior nephridia being modified to form peptonephridia in the first four segments.

Macroscopic Structure.—On opening the body wall micronephridia are seen to be present throughout all the segments. They take the form of small tubes attached to the body wall or

to the segments. They are much more numerous towards the anterior end, where they are arranged quite irregularly, giving a velvet-like appearance to the body wall. Towards the posterior end they become more regularly arranged, forming what appears to be a single row in each segment. Tufts of tubules attached to the alimentary canal, and regarded as peptonephridia by Beddard, are present in the first three segments, and are attached to the ventral surface of the alimentary canal.

Microscopic Structure.—The nephridia in the hinder part of the body, from where my series of sections were taken, proved to be infested with sporozoa. These lay in masses round the nephridia and septa, completely disguising the histology of the nephridium, and apparently causing the familiar appearance of the tissue lining the body cavity. No sporozoa were present in the circular or longitudinal muscles.

6.—*Perissogaster excavata*, Fletcher (7), p. 383;
syn. *Digaster excavata*, Fletcher.

No nephridiopores were visible.

The nephridia are micronephric, the anterior nephridia in the first four segments being modified to form peptonephridia, as in *Digaster armifera*.

Macroscopic Structure.—Again, as in *D. armifera*, micronephridia are present throughout, but are much more numerous towards the anterior end of the body. (Fletcher (8), p. 383.) Those in the first four segments are attached to the alimentary canal wall, and probably function as peptonephridia. A few nephridia in the three posterior segments of the body seem to remain attached to the alimentary canal near the anus, and are in all probability anal nephridia (c.f. Beddard (2), p. 49).

7.—*Megascolides australis*, McCoy (13);
syn. *Notoscolex gippslandicus*, Fletcher.

This form has been fully described by Professor Spencer in his Monograph on the Anatomy of *Megascolides australis* (14), so there is no need to describe the nephridial system in full.

but a short description is included here to complete the series I have worked, and diagrams are given. So far as I can ascertain there are only one or two minor points which appear to differ from the work published before.

No nephridiopores are visible.

Micro and meganephridia are present, also peptonephridia.

Macroscopic Structure.—Peptonephridia are present in segments 1-4; micronephridia in every segment after the fourth, attached to the outer walls of the segments. Meganephridia are present in addition, only in the more posterior portion of the body. In one specimen examined there were 330 segments, and typical meganephridia occurred from segment 180 to the posterior end, one pair in each segment. From segment 180 forwards [Fig. 12] a few large nephridia [Fig. 12, N¹] are present, but only here and there. These, though quite distinct from the micronephridia in size and position, have for the most part no funnels, but are still connected with the anterior septum. No nephridial funnels could be seen besides the single ones on either side of the nerve cord.

Microscopic Structure.—By means of sections the structure and arrangement of the various nephridia, and the ducts connecting them, can be more clearly ascertained. At the hinder end of the body there is in each segment a pair of meganephridia, each consisting of a funnel, a short, straight tube, and a coiled part, present on each side of the nerve cord. The funnel, as usual, opens into the segment anterior to the one in which the main part of the nephridium is situated; and through the wall of this latter segment a fine duct communicates with the exterior. [Fig. 13, N.d.] There is also present in the same segment many micronephridia [Fig. 13, n¹, n², n³], each of which gives off a single definite duct [n¹d., n²d., n³d.], which passes through the muscles of the body wall to the exterior, though it has apparently no internal opening. The ducts from both micro and meganephridia pass out singly between the blocks of longitudinal muscle fibres [Fig. 12, n¹d.), or through the fibres composing the block [Fig. 12, n²d.], and, branching among the circular muscles, form a regular network [n.c.l.] from which small single ducts pass, opening at irregular intervals on to the surface. Further forward, where the meganephridia

become irregular, there is a somewhat different arrangement, as the ducts from the micro- and meganephridia form a network [Fig. 14, n.i.] before passing out through the longitudinal muscles.

In no case could I find any connection from one segment to another by means of ducts, and though Professor Spencer (14) figured it, he was uncertain of its existence.

8.—*Woodwardia gippslandica*,¹ Spencer :

syn. *Cryptodrilus gippslandicus*.

Nephridiopores not very distinct, but, after careful examination, are seen to be present opposite and anterior to the third seta on each side of the body in each segment after the second, about halfway between the dorsal pores and the midventral line.

Meganephric.

Macroscopic Structure.—On dissection, one pair of meganephridia is seen to be present on the ventral surface of each segment, with the exception of the first and second. The funnel of each [Fig. 16, F.] lies close to the nerve cord in the ventral line. From the funnel a fine cord leads to a coiled mass of tubules, from which apparently a second fine duct passes off to a large muscular vesicle or bladder [Fig. 17], which opens to the exterior just anterior to the third seta. The vesicle is thin walled and transparent. The nephridia appear to be of the same structure all through the body.

Microscopic Structure.—On examining the nephridia of this form histologically, we find that the funnel is extremely small in relation to the size of the nephridium. The actual cells composing it were rather difficult to determine, but as far as could be ascertained they were marginal cells, columnar in shape, and, as usual, ciliated. From the funnel an extremely fine intracellular [Fig. 17, d.i.] duct passes through the septum to a large mass of definitely coiled tubules [17 c.n.]. From this mass is given off a single duct, intracellular again [V.d.], opening into the muscular bladder [V], which is, as in several other species examined, without doubt intercellular. This opens in its turn to the exterior, the opening [O.N.] being, as indicated by the

¹ Michaelsen, *ibid*.

small size of the nephridiopores, by a fine duct, passing from the vesicle, through the longitudinal and circular muscles, to the exterior, and opening near the anterior border of each segment. The cells of the epidermis are turned in at the opening, lining it for a short distance. I can find no trace of special muscles, as in *Woodwardia cooraniensis*, which could control the opening to the exterior. In this form, also, the vesicle [Fig. 17] has no caecum, the opening to the exterior being at the end of the bladder, away from the nerve cord.

9.—*Woodwardia cooraniensis*,¹ Spencer ;

syn. *Cryptodrilus cooraniensis*, Spencer (17).

Nephridiopores clearly marked. Though the openings in the many specimens vary somewhat in position in regard to the setae in the first five or six segments, they agree in being alternate down the rest of the body. The general arrangement seems to be that shown in the figure [Fig. 18], Spencer (17). The first three nephridia in segments 2, 3 and 4, open opposite the fourth seta, fourth, fifth and sixth opposite the third seta, seventh opposite fourth, eighth opposite second, and the rest alternating in position opposite fourth and second setae.

The nephridial system is meganephric.

Macroscopic Structure.—One pair of meganephridia is present in each segment after the first, and there are no micro- or pepto-nephridia. The most noticeable feature in the arrangement of the nephridia in the body is the alternation in the arrangement of the various parts of the nephridia to correspond with the alternation in position of the external openings. The nephridia are arranged in two distinct sets, the vesicle, which is of large size, being conspicuously placed towards ventral [Fig. 19, A.] or dorsal [Fig. 19, B.] line, as the nephridiopores open opposite the second or fourth seta respectively. Very little more than the general arrangement of the nephridia could be seen by dissection, and the position of the funnels, which are extremely small, could not be determined.

¹ Michaelsen, *ibid.*

Microscopic Structure.—Transverse serial sections of this form show the funnel to be very small, and, unlike the nephridiopores, constant in position, being situated between the first and second setae from the midventral line on each side. [cf. Benham, (4)]. The general arrangement shown in the figure (20) is reconstructed from a series of sections. As can be seen, the same parts are present in both nephridia, the coils differing in length, according as the vesicle opens dorsally [Fig. 20, O.N.B.] or ventrally [O.N.A.]. The histology of one of my series was particularly good, so that the structure of the various parts could be worked fairly completely. The funnel is very small, formed by a few marginal cells, columnar in shape, and ciliated. The tube leading from this divides into two parts, the thinner one of which passes at once to the vesicle, being shorter in nephridium A than in B; while the thicker one in both nephridia coils in definite ways and ends blindly. In section, the tube leading from the funnel is seen to contain an intracellular duct which, at the point X passes into the coiled tube c.n. [Fig. 20]. It continues as a straight lumen as far as the blind end [Fig. 20, Y.], where a section shows clearly that the lumen turns back on itself, and becoming somewhat wider, coils slightly in the thickness of the tube until it reaches point X again, where the duct passes as a single straight lumen to open into the vesicle [o.v.]. This arrangement is strictly comparable with that of the nephridium of *Lumbricus* described by Benham (3), the intracellular straight lumen being Benham's "narrow tube," while the wider coiled part resembles the wide tube described by him. The vesicle also is extremely thin walled, and apparently composed of a single layer of irregular muscle cells lined by very thin epithelial cells. The opening of the vesicle to the exterior is extremely well-marked, the lining of the vesicle distinctly changing from flattened to cubic epithelial cells, which, in their turn, give place to the columnar cells continuous with those of the external surface of the body [Fig. 21] and, like them, covered by a thin cuticle. The arrangement of the muscles is characteristic, as, in addition to the ordinary circular and longitudinal muscle bands, there is a distinct group of muscle fibres round the external opening, which appears to form a "sphincter" controlling the opening of the nephridium to the exterior [Fig. 21].

There is no trace at all of any network of nephridial ducts in this species, each nephridium being absolutely distinct from all others, with its own openings, interior and exterior.

In several specimens examined for the nephridia, only those of the anterior half of the body were in good preservation, the rest of the body being infested with some sporozoan form, which was present in such numbers as to disguise completely the histology of the nephridia when sections were cut.

- 10.—**Notoscolex queenslandica**,¹ Spencer ;
syn. *Cryptodrilus queenslandica*, Spencer (5).

No nephridiopores visible.

Nephridial system micronephric.

Macroscopic Structure.—The micronephridia are present in every segment of the body with the exception of the first. Towards the anterior end, in segments four to five, they are extremely minute and numerous, and are arranged quite irregularly, lining the whole of the inner wall of the segment. Behind the first few segments, however, though still very minute, they are no longer indefinitely arranged, but form a single row in each segment attached to the wall, about the centre of the segment, between the two branches of the nerve cord.

- 11.—**Fletcherodrilus unicus**, Fletcher, var. *major*, Spencer (17).

The nephridiopores are well marked and are situated opposite and anterior to the fourth seta from the midventral line on either side of the body, except those on segments 2, 3 and 4, which are slightly dorsal to the setae. [Fig. 22.] Fletcher (15), p. 1540.

Nephridial system meganephric.

Macroscopic Structure.—On dissection one pair of meganephridia is seen to be present in each segment after the first. There are no micronephridia or peptonephridia present. The nephridia of the anterior segments of the body are very much

¹ Michaelsen *ibid*

larger, with proportionally smaller and more muscular-looking vesicles [Fig. 24], while those of the rest of the body have much smaller coils, but the vesicles are large and have transparent walls. [Fig. 25.] The vesicles form a most conspicuous feature of the nephridial system, and the nephridia were of such large size that their general arrangement could be seen microscopically. [Fig. 23.]

The parts seen are closely similar to the nephridia of *Woodwardia cooraniensis*, though in the case of *F. unicus* there is no alteration in the arrangement of the nephridia.

The funnel (F) lies near the midventral line of the body, opening between the ventralmost seta and the nerve cord, and connecting by a fine thread passing through the septum, with two portions—(1) a somewhat coiled tube which ends blindly; and (2) a fine duct which connects with the large muscular vesicle, which in its turn opens to the exterior.

Microscopic Structure.—An examination of sections of this earthworm shows that the funnel is composed of a single row of marginal cells, columnar in shape, and ciliated. Figure 26 shows diagrammatically the various parts present. From the funnel (F) a duct leads by means of a fine intracellular lumen connecting with the main part of the nephridium, as mentioned above. [Fig. 25, d. i.] This lumen can be distinctly traced through the greater part of the long coil figured as c.n. [Fig. 26]. But, as well as this somewhat straight lumen, there is a coiled tube present, which apparently passes back from the blind end (Y) along the whole length of the coil (c.n.), and then continues as the fine intracellular duct (v.d.) leading to the bladder. Unfortunately the histology of my series was not very good, and I was unable to see the transition between the cells forming the duct (v.d.), and the flattened cells forming the wall of the bladder itself. The opening of the vesicle to the exterior is provided with a number of flattened, unstriated, vesicle cells, forming a sphincter. The very thin flat cells lining the vesicle, pass into cubic epithelial cells, and these into the ordinary epithelial cells of the outer body wall. This species somewhat closely resembles *Woodwardia cooraniensis* [Fig. 21], except that in the latter there is no such sphincter muscle present as I have described above.

12.—*Fletcherodrilus unicus*, Fletcher;syn. *Cryptodrilus* ? *unicus*, Fletcher (7), p. 1540*C. purpureus*, Michaelsen (11), p. 3*Cryptodrilus* ? *purpureus*, Fletcher (8), p. 990*C.* ? *fasciatus*, Fletcher (8), p. 988*Fletcherodrilus unicus*, Michaelsen (12), p. 29.

After careful examination of this form, and cutting series of sections, I can find no difference between its nephridia and those of Professor Spencer's variety, *F. unicus*, *var major*. [Also see Spencer (17)].

BIBLIOGRAPHY.

- (1) Beddard.—On certain Points in the Structure of Urochaeta. E.P. and Dichogaster, nov. gen., with further remarks on the Nephridia of Earthworms. Q.J.M.S., vol. xxi.
- (2) Beddard.—Monograph of the Order of the Oligochaeta.
- (3) Benham.—The Nephridium of Lumbricus and its Blood Supply, with Remarks on the Nephridia of other Chaetopoda. Q.J.M.S., vol. xxxii., n.s., 1891.
- (4) Benham.—Notes on Two Acanthodrilid Earthworms from New Zealand. Q.J.M.S., vol. xxxiii., n.s., 1892.
- (5) Fletcher.—Notes on Australian Earthworms, Part I. Proc. Linn. Soc. N.S.W., vol. i., Series 2.
- (6) Fletcher.—Notes on Australian Earthworms, Part II. Proc. Linn. Soc. N.S.W., vol. i., Series 2, 1886.
- (7) Fletcher.—Notes on Australian Earthworms, Part III. Proc. Linn. Soc. N.S.W., vol. ii., Series 2, 1887.
- (8) Fletcher.—Notes on Australian Earthworms, Part IV. Proc. Linn. Soc. N.S.W., vol. ii., Series 2, 1887.
- (9) Fletcher.—Notes on Australian Earthworms, Part V. Proc. Linn. Soc. N.S.W., vol. ii., Series 2, 1888.
- (10) Fletcher.—Notes on Australian Earthworms, Part VI. Proc. Linn. Soc. N.S.W., vol. iv., Series 2, 1889.
- (11) Michaelsen.—J. B. Hamb. wiss Aust. vi., 1889.
- (12) Michaelsen.—J. B. Hamb. wiss Aust. viii., 1891.
- (13) McCoy.—Prodromus of Zoology of Victoria, Dec. 1, Pl. 7.

- (14) Spencer.—The Anatomy of *Megascolides australis*. Trans. Roy. Soc. Vic., vol. i., part i., 1888.
- (15) Spencer.—Preliminary Description of Victorian Earthworms, Part I. Genera *Cryptodrilus* and *Megascolides*. Proc. Roy. Soc. Vic., 1891, Art. xvii.
- (16) Spencer.—Preliminary Notice of Victorian Earthworms, Part II. Genus *Perichaeta*. Proc. Roy. Soc. Vic., 1892, Art. I.
- (17) Spencer.—Further Descriptions of Australian Earthworms, Part I. Proc. Roy. Soc. Vic., Aug., 1900, vol. xiii. n.s., part 1.

EXPLANATION OF PLATES.

- Fig. 1.—*Megascolex dorsalis*. Diagram to show relative positions of dorsal and ventral meganephridia, and the segments in which they occur.
- 2.—Diagrammatic section of one of same through funnel, compiled from three consecutive sections to show the large ciliated cells (c) forming the funnel.
- 3.—Dorsal meganephridium of same.
- 4.—Diagram of posterior segments of the body, with dorsal and ventral meganephridia and the duct (d.c.) connecting the two.
- 5.—*Megascolex fielderi*. Diagram to show number and position of the funnels in one specimen on one side of the body. The body wall is represented as opened out.
- 6.—Drawing of same to show nephridia in situ, from posterior end of body.
- 7.—Somewhat diagrammatic transverse section through body wall. Shows arrangement of nephridial ducts passing out through the muscles to the exterior, and the connective tissue joining the nephridia.
- 8.—*Diporochaeta davallia*. Drawing of nephridium to show relative positions of the coils, with the pigmented coil (p.c.n.) and the fine intracellular duct (i.d.) opening to the exterior.

Fig. 9.—Funnel of same, showing arrangement of the 20 marginal cells, and the cubic-shaped cells lining the duct from the funnel.

10.—Somewhat diagrammatic transverse section through coils of a nephridium, showing pigment granules (p.g.) in the cells lining the pigmented coil.

11.—*Diporochaeta grandis*. Drawing of nephridium, mounted whole in glycerine.

12.—*Megascolides australis*. Diagram of arrangement of meganephridia in part of a specimen. From 160 to 180 only a few large nephridia are present, most of which (N^1) though attached to the anterior septum, have no funnel.

13.—Diagrammatic transverse section of same near posterior end of body, to show arrangement in one section of the mega- and micronephridia and the ducts for them.

14.—Diagrammatic longitudinal section of same where meganephridia are beginning to become irregular, showing arrangement of ducts from mega and micronephridia, and their connection on their way to the exterior.

15.—Diagrammatic longitudinal section showing same near posterior end.

16.—*Woodwardia gippslandica*. Diagram of five meganephridia in situ on left-hand side of body, to show relative positions and size of funnel (F), nephridial coils (c.n.), vesicle (V), and opening to exterior.

17.—Diagrammatic nephridium of same, showing relation of the several parts to one another.

18.—*Woodwardia cooraniensis*. External view, showing positions of openings of the nephridia and their relation to the setae.

19.—Semi-diagrammatic drawing near posterior end of body of same, to show six nephridia in situ with those on right-hand side of body, opening opposite 2nd seta (A) and opposite 4th seta (B) alternately.

20.—Enlargement of same, showing two consecutive nephridia and their various parts.

- Fig. 21.—Section of opening of nephridium of *W. cooraniensis* to exterior, showing arrangement of muscles, and the gradual change in character of the epithelium from the ordinary external cells to the flattened cells lining the vesicle.
- 22.—*Fletcherodrilus unicus*, v. *major*. External, showing positions of openings of the nephridia to the exterior, with regard to the setae.
- 23.—Diagrammatic drawing of same, to show six nephridia in situ on left-hand side of body, with the position of funnel, vesicle, coils and opening to exterior in relation to the setae.
- 24.—Drawing of left-hand nephridium of segment 6 in situ, showing relatively small size of the vesicle, which is thick-walled.
- 25.—Drawing of a left-hand nephridium near posterior end of body in situ, showing large thin-walled vesicle, and relation of coils of nephridium to it.
- 26.—Diagram illustrating description of nephridia of same, with the various parts lettered.

REFERENCE LETTERS.

Roman numerals indicate position of setae, numbering in order from the nerve cord towards dorsal pore.

Numbers refer to numbers of segments.

Arrow points to anterior end.

A	Nephridium opening ventrally opposite 2nd seta
A. C.	Alimentary canal
B.	Nephridium opening ventrally opposite 4th seta
c.	Cells forming funnel
c. c.	Cubic cells lining entrance to intracellular duct
c. d.	Connective tissue containing ducts from meganephridia
cil.	Cilia
c m.	Marginal cells of funnel
c. n.	Nephridial coils
c. n. p.	Pigmented coil of nephridium

c. t.	Connective tissue
c. t. l.	Connective tissue between blocks of longitudinal muscle
cut.	Cuticle covering epidermis
cub. epi.	Cubic epithelial cells
d. c.	Duct connecting dorsal and ventral meganephridia
d. i.	Intracellular duct leading from the funnel
epi.	Epidermis
F.	Funnel
g. c.	Goblet cells
i. c.	Cells lining intracellular duct
i. d.	Lumen of intracellular duct
m.	Muscles
m. c.	Mass of cells round preseptal portion of intracellular duct
m. circ.	Circular muscles cut in section
m. d.	Marginal duct passing round bladder and connective tissue
m. long.	Longitudinal muscles cut in section
M. S.	Muscles forming sphincter
N.	Meganephridia
N ¹ .	Large nephridium with no funnel, but connected with the anterior septum
N. C.	Nerve cord
N. D.	Dorsal meganephridia
N. d.	Duct from meganephridium to sinus between longitudinal and circular muscles
N. v.	Ventral meganephridia
n., n. ¹ , n. ² , n. ³	Micronephridia
n. c. l.	Network of nephridial ducts between circular and longitudinal muscles
n ¹ . d.	Duct from 1st micronephridium to sinus between longitudinal and circular muscles
n ² . d.	Duct from 2nd micronephridium to sinus between longitudinal and circular muscles
n. ³ d.	Duct from 3rd micronephridium to sinus between longitudinal and circular muscles
neph.	Nephridia

